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ABSTRACT

This course in advanced biology is entitled "Advanced Genetics" and is one of a series of instructional guides prepared by teachers for the Sahuarita High School (Arizona) Career Curriculum Project. It consists of seven units of study, and 15 behavioral objectives relating to these units are stated. The topics covered include a review of genetics, Drosophila characteristics, yeast irradiation, human genetics, investigating a yeast mutant, probability and Chi-square, and preparation of a scientific paper. The units provide a statement of the rationale, objectives, sources of information, a series of student activities, and a post-evaluation. For related units in this series see SE 016 635 - SE 016 644. (JR)

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ED 080372

SAHUARITA HIGH SCHOOL

CAREER

CURRICULUM

PROJECT

COURSE TITLE: ADVANCED BIOLOGY

PACKAGE TITLE: ADVANCED GENETICS

BY

LARRY CHRISTENSEN

SE 016 638

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Advanced Genetics

Introduction:

Genetics is one of the fastest moving areas of Biology right now. When you consider what effects each breakthrough in Genetics could have you can see why it is important. New foods, new ways to combat diseases, prevention of birth defects and human transplants are only some of the areas where genetics is the basis for new understanding.

In this course you will be asked to do a large amount of reading and thinking on your own. There will be little time to waste. You will be dealing with many living materials and a rigid time schedule will be important. Your time will be much better spent in lab if you have done your reading BEFORE coming to class. If you work diligently and come to class prepared, this quarter will pass quickly and pleasantly. Good luck!

Objectives

1. Career Cluster - Health Occupations

2. Areas - Medical Research
   Bacteriology
   Medical Technician
   Nursing
   Nurse's Aid

3. Objectives

   1. You will have a basic knowledge of genetics and be able to pass a written test on the programmed text "Heredity" at the 90% level.

   2. Identify, name, and order the stages in the life cycle of D. melanogaster.

   3. Identify the body parts and distinguish the sexes of D. melanogaster.

   4. Identify and distuinguish males and females of wild type and selected mutants of D. Melanogaster.

   5. Describe techniques for isolating virgin females of Drosophila.

   6. Construct reciprocal crosses using males and virgin females of selected mutants of Drosophila.

   7. Construct a bottle population of Drosophila using males and females of stipulated phenotypea.

   8. You will demonstrate your ability to use a hemacytometer in obtaining cell counts of yeast cells.

   9. You will be able to describe a procedure for obtaining an ultraviolet irradiation kill curve in yeast.

   10. You will be able to construct a graph of an UV kill curve and predict the time of irradiation required to obtain a 5-10% survival.

   11. Given certain characteristics you will demonstrate how to determine your own genotype and will compare them with rest of the class.

   12. You will demonstrate a method of isolating a nutritional mutant strain of yeast.

   13. You will be able to calculate a probability value for a given set of data using the chi-square method.

14. You will be able to apply the Hardy-Weinberg equation to calculate gene and genotype frequencys in a given population.

15. You will be able to write a scientific paper, of publishable quality, communicating the results of your Drosophila crosses using as a model one of the attached papers from a biological journal.

SAHUARITA HIGH SCHOOL

CAREER

CURRICULUM

PROJECT

COURSE TITLE: ADVANCED BIOLOGY

PACKAGE TITLE: ADVANCED GENETICS
Unit 1 - Review of Genetics

BY

LARRY CHRISTENSEN

Advanced Genetics

Unit I - Review of Genetics

RATIONALE:

You have all completed a basic Biology course and have some idea what genetics is all about, but to refresh your memory your first assignment is to review and fill in any gaps.

Objectives

1. You will have a basic knowledge of genetics and be able to pass a written test on the programmed text "Heredity" at the 90% level.

Information Sources

1. EMI Programmed Biology Series - "Heredity"

Activities

None

Post-Evaluation

Complete the written test for "Heredity" with a score of at least 90%.

SAHUARITA HIGH SCHOOL

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PROJECT

COURSE TITLE: ADVANCED BIOLOGY

PACKAGE TITLE: ADVANCED GENETICS
Unit II - Drosophila Characteristics

BY

LARRY CHRISTENSEN

Advanced Genetics

Unit II - Drosophila Characteristics

RATIONALE:

A large part of this course will be devoted to an experimental test cross using the fruitfly Drosophila melanogaster. This fly is easily cultured and its generation time is only about two weeks at room temperatures. The fruitfly has been the subject of genetic studies since about 1909.

In order to recognize some of the mutant strains it is necessary to know a certain amount of the anatomy of the fly and its life cycle.

OBJECTIVES:

1. Identify, name, and order the stages in the life cycle of D. Melanogaster.
2. Identify the body parts and distinguish the sexes of D. melanogaster.
3. Identify and distinguish males and females of wild type and selected mutants of D. melanogaster.
4. Describe techniques for isolating virgin females of Drosophila.
5. Construct reciprocal crosses using males and virgin females of selected mutants of Drosophila.
6. Construct a bottle population of Drosophila using males and females of stipulated phenotypes.

INFORMATION SOURCES:

1. Read the Drosophila Manual
2. Study sheets G-1 and G-2.

Activities:

1. Using your Drosophila manual and lab sheets identify the body parts and sexes of various wild type and mutant flies.

2. Describe in writing the technique you will use for assuring you have selected only virgin female flies for your crosses. DO NOT set up any crosses until your instructor has approved your techniques.

3. After you have satisfied your instructor that you are ready to proceed, obtain 2 different strains of Drosophila melanogaster and set up your recipical crosses. Be sure to check with your instructor about ANY questions you might have. This is very important for any mistake you make at this point will cause your cross to be meaningless and make your report (Unit VII) almost impossible to complete.

4. Construct a population of Drosophila following the instructions given on Sheet G-3.

Post-Evaluation:

1. Identify, name, and order the stages in the life cycle of D. Melanogaster from memory, with no errors.

   ☐ Completion Instructor's Initials _____

2. Identify the body parts and sex of the flies under the microscope at the back of the room. Check with your instructor for an oral examination.

   ☐ Completion Instructor's Initials _____

3. Hand in your written procedure for the technique you will use in isolating virgin females.

   ☐ Completion Instructor's Initials _____

4. Have your instructor check your recipical crosses. Be able to answer any questions about the techniques you used.

   ☐ Completion Instructor's Initials _____

5. Have your instructor check your population bottles. Be able to answer any questions about the techniques you used.

   ☐ Completion Instructor's Initials _____

The following material has been deleted: Sheet G-1

Sheet G-2

F_1 Information

SECTION _____

NAME _____

DUE DATE _____

DATA FROM DROSOPHILA CROSS

	Cross "A"	Cross "B"
1. Parental cross (P_1)		
	Code of males _____	Code of males _____
	Code of females _____	Code of females _____
2. F_1 Types and Numbers		
	Code _____ males _____	Code _____ males _____
	females _____	females _____
	Code _____ males _____	Code _____ males _____
	females _____	females _____
	Both codes _____ males _____	Both codes _____ males _____
	females _____	females _____
	Wild types _____ males _____	Wild types _____ males _____
	females _____	females _____
	Total males _____	Total males _____
	Total females _____	Total females _____
	Total males and females _____	Total males and females _____
3. Ratios of F_1.		

Sheet G-3

Drosophila Populations

Why do certain genes compared to their alleles appear in a greater frequency within a group or population of organisms? Is it because individuals possessing those certain genes have a better chance of survival and reproduction than if they possessed the alleles? If a particular gene is beneficial to the reproduction of an organism why doesn't its allele disappear from the population?

These are questions which arise when the genetics of populations are investigated. In this portion of this exercise we want to begin our studies of genes in populations.

A short time ago five female Drosophila heterozygous for a recessive mutation and five males homozygous for the same mutation possessed by the female were introduced into a prepared bottle. The F_1 of these flies have been produced and are now mating to produce the F_2.

If males and females of this F_1 are placed in a bottle containing fresh medium, "eggs" laid by the females will hatch to produce F_2 individuals. If the F_1 and F_2 flies are allowed to be present in the same bottle matings may not only occur between individuals of the F_2 generation but between individuals of the F_1 and F_2 generations. Such matings may be at random and hence similiar to the mating patterns displayed in natural groups of many animal and plant populations.

As a result of the population increase there is a consequent competition for food in the bottle. Through subsequent generations further competition may be expected. Often this competition results in changes of genetic types within the population. The shift in genetic types is reflected in the frequencies of the genes being investigated.

Because of the limited food supply in the bottle the population will eventually decline in numbers. As this decline begins the original bottle is connected by a short length of automotive radiator hose to a second bottle containing fresh medium. The ends of the tubing fit over the necks of the two bottles. Aluminum foil caps having three quarter-inch holes are placed on each bottle mouth. Thus flies can move freely from one bottle to another but larvae are prevented from contaminating one bottle with food from the other. The connecting hose has an half-inch perforation stoppered with cotton to permit ventilation of the unit. The unit is then placed flat in a storage box which has one open end. The bottom of the newer bottle of medium of the pair is placed at the open end of the box.

When the fresh bottle of medium is added to the population unit the population of flies will again flourish. As the food is depleted in the second bottle the population will again decline. As the decline begins a fresh bottle of medium replaces the original bottle of the unit with the bottom of the newer bottle of the pair at the open end of the box.

Two or three days following the introduction of the fresh medium ether is dropped on the cotton plug in the connecting hose. As the flies get groggy the unit is opened, the flies further anesthetized, if necessary, classified and counted and returned to the newer bottle of the unit. The unit is reassembled and returned to the storage box. Decline, fresh medium bottle and population count is repeated as necessary until the experiment is concluded.

MAKE OBSERVATIONS OF F_1 FLIES. PLACE SEVERAL ETHERIZED MALES AND FEMALES OF THE F_1 ON A SMALL PIECE OF PAPER AND PLACE THE PAPER GENTLY ONTO THE SURFACE OF THE SPECIALLY PREPARED AGAR SLANT IN THE HORIZONTAL FLY BOTTLE. RECORD THE ORIGINAL FREQUENCIES OF THE P_1 AND THE F_1 IN PROPER PLACES ON SHEET G-3a.

Similar populations of flies having the same gene frequencies may show differences with regard to changes in these frequencies under different environmental conditions. One environmental factor which may greatly affect gene frequencies is temperature. Higher temperature may change the gene frequency of a population in one direction as opposed to a similar population at a lower temperature.

MARK THE POPULATION BOTTLE WITH YOUR NAME, SECTION NUMBER, AND THE TEMPERATURE TO WHICH YOUR BOTTLE IS ASSIGNED. PLACE YOUR BOTTLE IN THE APPROPRIATE STORAGE BOX.

The following material has been deleted: Sheet G-3a Drosophila Populations

SAHUARITA HIGH SCHOOL

CAREER

CURRICULUM

PROJECT

COURSE TITLE: ADVANCED BIOLOGY

PACKAGE TITLE: ADVANCED GENETICS
Unit III - Yeast Irradiation

BY

LARRY CHRISTENSEN

Advanced Genetics

Unit III - Yeast Irradiation

RATIONALE:

Genes within the chromosomes of yeast are known to change (mutate) spontaneously. These changes produce chemical alterations within the organism which may be reflected in the type of medium upon which it can grow. These mutations can be increased in number through the use of certain forms of radiation. Ultraviolet irradiation is an agent which can increase the rate of change within the genetic material.

It has been found, that for the isolation of mutant strains, a UV dose which allows 5-10% survival of the cells gives the highest proportion of mutants. To determine the time of irradiation needed with the 2537 A UV lamp at a fixed distance from the culture a survival curve must be constructed.

OBJECTIVES:

1. You will demonstrate your ability to use a hemacytometer in obtaining cell counts of yeast cells.
2. You will be able to describe a procedure for obtaining an ultraviolet irradiation kill curve in yeast.
3. You will be able to construct a graph of an UV kill curve and predict the time of irradiation required to obtain a 5-10% survival.

INFORMATION SOURCES:

1. Sheet G-4.
2. Instructor lectures.
3. "Genes and Populations"

ACTIVITIES:

1. Obtain a yeast suspension and a hemacytometer from the instructor and make an accurate count of the number of cells/ml in the suspension. Give your results to your instructor.

2. Write out your procedure for obtaining an UV irradiation kill curve for yeast. Hand in to your instructor.

3. After your instructor has checked your procedure, obtain the necessary materials and irradiate 5 plates (+ one control) of yeast suspension for the time given you by the instructor. When you have obtained your survival data write it on the chalkboard in the place designated.

4. Using all of the class data construct a graph, plotting survival rate (%) v.s. time of irradiation and predict the time of irradiation that would produce a 5-10% survival rate in yeast.

5. See attached sheet!

POST-EVALUATION:

1. Obtain the exam for "Genes and Populations" from your Instructor. Passing = 90% correct.

   ☐ Complete Instructor's Initials_____

2. Completion of Activity 1.

   ☐ Complete Instructor's Initials_____

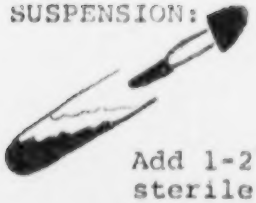
3. Completion of Activity 2.

   ☐ Complete Instructor's Initials_____

4. Hand in your graph and mediction

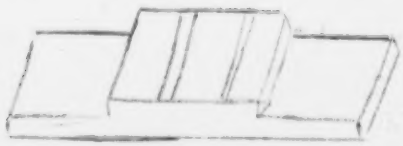
   ☐ Complete Instructor's Initials_____

1. SUSPENSION:



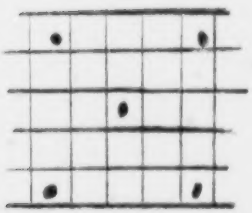
Add 1-2 ml. of sterile H_2O to yeast slant; shake till cloudy.

2. HEMACYTOMETER:



Transfer a drop of yeast suspension to hemacytometer, then put the coverglass in place and allow the cells to settle.

3. COUNT:



1 mm.

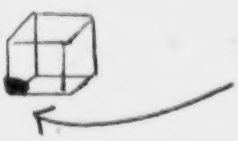
Hemacytometer dimensions:

1 mm. x 1 mm. x 0.1 mm. volume = 0.1 cubic millimeters (mm^3)

Count 5 large squares indicated above. Do not count if cells clumb then pour suspension from slant into 25 ml. flask. Add 1 ml. sterile H_2O; shake well.

4. CONVERSION:

a. Convert 5 large sq. count to 0.1 mm^3 ---multiply by 5.
b. Convert 0.1 mm^3 to 1 mm^3 (1 cm^3 = 1 milliliter)---multiply by 10.
c. Convert 1 mm^3 to 1 cm^3 --- multiply by 1000.



1 cubic centimeter (1 cm^3) = 10mm x 10 mm

1 cubic millimeter (1 mm^3)

5. EXAMPLE:

a. Cell count of 5 large sq. = 59, 60, 62, 65, 54 = 300
b. 300 x 5 = 1500 cells/0.1 mm^3 = 1.5×10^3 cells/.1 mm^3
c. $(1.5 \times 10^3) \times 10 = 1.5 \times 10^4$ cells/mm^3
d. $(1.5 \times 10^4) \times 1000 = 1.5 \times 10^7$ cells/ml.

6. If the suspension is <u>below</u> the concentration of 1×10^7 cells/ml. then take the slant and shake until the suspension becomes more cloudy. Repeat count.

7. If the suspension is above the 1×10^7 conc., dilute it down as follows: (next page)

a. Example count = 3.3×10^{10} --- round off to 3×10^{10}
b. 10^3 fold dilution --- 3×10^7 (0.1 ml. of suspension, 3 drops from a Pasteur pipette, added to a flask containing 99.9 ml. of sterile water).

8. Remove 0.1 ml. (3 drops) of this suspension and dilute 10^3 fold (0.1 to 99.9).

9. Plate 0.4 ml. (12 drops) of this suspension on 6 plates and label the top with the time assigned by your instructor, and control plus your names. Take spreader and spread suspension.

10. Remove the cover from the petri plate and irradiate in complete DARK with UV light at a distance of approximately 74 cm., replace cover and place upside down while still DARK into a light tight box.

11. After 3-4 days remove your petri dishes from the dark boxes and count the colonies. If the cells were plated properly on the surface of the medium each visible colony will represent the position and offspring of one surviving cell.

12. Graph your results.

ACTIVITY 5

Prepare a yeast solution on a petri dish of complete medium and irradiate for the length of time you have determined would give a 5-10% survival rate. This should produce the maximum number of mutations. Put your irradiated culture in a dark box. These cultures will be used in Unit V.

SAHUARITA HIGH SCHOOL

CAREER

CURRICULUM

PROJECT

COURSE TITLE: ADVANCED BIOLOGY

PACKAGE TITLE: ADVANCED GENETICS
Unit IV - Human Genetics

BY

LARRY CHRISTENSEN

ADVANCED BIOLOGY

OBJECTIVES

ADVANCED GENETICS

1. You will have a basic knowledge of genetics and be able to pass a written test on the programmed text "Heredity" at the 90% level.

2. Identify, name, and order the stages in the life cycle of D. Melanogaster.

3. Identify the body parts and distinguish the sexes of D. Melanogaster.

4. Identify and distinguish males and females of wild type and selected mutants of D. Melanogaster.

5. Describe techniques for isolating virgin females of Drosophila.

6. Construct reciprocal crosses using males and virgin females of selected mutants of Drosophila.

7. Construct a bottle population of Drosophila using males and females of stpulated phenotype.

8. You will demonstrate your ability to use a hemacytometer in obtaining cell counts of yeast cells.

9. You will be able to describe a procedure for obtaining an ultraviolet irradiation kill curve in yeast.

10. You will be able to construct a graph of an UV kill curve and predict the time of irradiation required to obtain a 5-10% survival.

11. Given certain characteristics you will demonstrate how to determine your own genotype and will compare them with rest of the class.

12. You will demonstrate a method of isolating a nutritional mutant strain of yeast.

13. You will be able to calculate a probability value for a given set of data using the chi-square method.

14. You will be able to apply the Hardy-Weinberg equation to calculate gene and genotype frequencys in a given population.

15. You will be able to write a scientific paper, of publishable quality, connumicating the results of your Drosphila crosses using as a model one of the attached papers from a biological journal.

Advanced Genetics

Unit IV - Human Genetics

RATIONALE:

In any group or population of organisms, unless breeding is controlled experimentally, or by certain environmental conditions, or as in numerous plant species which are self-fertilizing, it is unusual to find two individuals exactly alike. Among humans, except for identical twins, it is highly improbable that two persons would be genetically identical.

The purpose of this unit is to demonstrate the genetic variation among humans within a relatively small group.

OBJECTIVES:

1. Given certain characteristics you will demonstrate how to determine your own genotype and will compare them with rest of the class.

INFORMATION SOURCES:

1. Review the programmed text Exercises in Genetics.
2. Instructor lectures.

ACTIVITIES:

1. HUMAN CHARACTERISTICS

There are a large number of human characteristics which may be used in studying human variation. However, some are more easily observed and distinguished than others. A number of these traits are described below so that you can determine the particular phenotype which you possess in each instance. As you determine the phenotype for each characteristic turn to page 53 and if a space is provided place a check-mark before the particular genotype responsible for your phenotype.

A. Ear lobes - may be pendulous (free) or non-pendulous. Pendulous (L) is dominant to non-pendulous (ll).

B. Double-jointed thumbs - the ability to throw the thumb out of joint is a dominant trait (D), which is dependent upon the presence of loose ligaments.

C. Mid-digital hair - the presence of hair on the middle segments of the fingers is dominant to the lack of hair (hh).

D. Bent little finger - the end segment of the little fingers may be straight (pp) or bent toward the adjacent finger (P).

E. Handeness - the "southpaw" (left-handed) pitcher versus the right-handed batter is an important part of baseball strategy. Left-handedness appears to be inherited as a recessive trait and hence, right-handedness is dominant (R).

F. Hair shape - whether your hair is straight or curly apparently is determined by multiple alleles. Curly hair is dependent upon the homozygous alleles (cc). An alternate pair (CC) determines straight hair, while the heterozygote has wavy hair.

G. Hair color - this is dependent upon several genes but the genotypes can be simplified by considering only the larger classifications. Persons with dark hair have the genotype (D_R_); those with red hair (D_rr); those with blonde hair (ddR_) and those with sandy hair (ddrr).

H. Eye color - the presence of pigment in the iris of the eye is determined by the presence of several factors but these can be expressed by the genotype (B_). An individual with blue eyes lacks pigment in the iris (bb).

I. Tasters - the ability to taste particular substances is dependent in certain instances upon the presence of a dominant gene.

1. Phenylthiocarbamide - place a small piece of this paper in your mouth. If you taste nothing distinctive you are a non-taster (tt).
2. Thiourea - test for tasting this substance the same as above. The lack of taste indicates a recessive genotype (zz).

J. Blood types - are dependent upon a series of multiple alleles. Two antigens A and B which are found in the blood of man determine the blood group to which individuals belong. People with both A and B antigens in their blood belong to blood group AB and have a genotype (I^AI^B); those with antigen A only belong to group A and genotypically are (I^AI^A) or (I^Ai). Individuals who have only antigen B have a genotype of (I^BI) or (I^Bi) and have B type blood. Many people lack both antigens and are

relegated to the fourth blood group O. These people have a genotype of (ii).

In this series of alleles gene (i) is recessive to both gene (I^A) and gene (I^B). Genes (I^A) and (I^B), which are responsible for the production of antigens A and B respectively within individuals, show codominance.

Following the directions in the LAB-AIDS kit type your blood.

K. Rh^+ and Rh^- is another blood factor that is very important when blood is considered for transfusions.

Following the directions in the LAB-AIDS kit type your blood.

L. Tongue curling - if the tongue is extended many individuals can then cause it to curl up at the sides. The ability to do this appears to be a dominant trait (S). Far fewer people can roll their tongue backwards or fold it front to back. This also appears to be the result of a dominant gene.

DETERMINE YOUR GENOTYPES FOR THE CHARACTERS ABOVE. CHECK PROPER GENOTYPES ON PAGE 53. (Sheet G-5)

GENETIC PATTERN

In order to demonstrate the degree of genetic variability in a relatively small sample of the human population we will make use of certain of the genotypes on page 53. Notice that the traits represented on Shee G-5 are listed by an alphabetical letter (e.g., A for ear lobes). Certain of these traits have a number to the right of the possible genotypes. To find your pattern record the number appearing beside certain of the pertinent genotypes you have checked, in the block indicated by the letter for the trait where genetic pattern is indicated. After all students have recorded their genetic pattern the instructor will survey the class for the presence of similiar patterns.

POST-EVALUATION:

1. Hand in Sheet G-5.

☐ Complete Instructor's Initials_____

Sheet G-5

HUMAN CHARACTERISTICS

SECTION _____

NAME _____

(Place a check in front of your genotype for each of the characteristics listed below.)

CHARACTER	GENOTYPE
A. Ear lobes	
	____ (L-) 1
	____ (ll) 2
B. Thumbs	
	____ (D-)
	____ (dd)
C. Mid-digital hair	
	____ (H-)
	____ (hh)
D. Bent little finger	
	____ (P-)
	____ (pp)
E. Handedness	
	____ (R-)
	____ (rr)
H. Eye color	
	____ (B-) 3
	____ (bb) 4
I. Taster	
1. PTC	
	____ (T-) 5
	____ (tt) 6
2. Thiourea	
	____ (Z-)
	____ (zz)
J. Blood types	
	____ ($I^A I^A$) ($I^A i$)
	____ ($I^B I^B$) ($I^B i$)
	____ ($I^A I^B$)
	____ (ii)
K. Rh factor	
	____ Rh^+ 7
	____ Rh^- 8
L. Tongue curling	
	____ (S-) 10
	____ (ss) 11

Genetic pattern

A	H	I	K	L

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PROJECT

COURSE TITLE: ADVANCED BIOLOGY

PACKAGE TITLE: ADVANCED GENETICS
Unit V - Investigating a Yeast Mutant

BY

LARRY CHRISTENSEN

Advanced Genetics

Unit V - Investigating a Yeast Mutant

Rationale:

One problem a research geneticist often encounters is a new mutant strain of some organism. It is his job to determine just what biosynthetic pathway has been blocked. In this unit you will investigate one technique often used.

Objectives:

1. You will demonstrate a method of isolating a nutritional mutant strain of yeast.

Information Sources:

1. Read DNA - The Key to Life.
2. Instructor lectures.

Activities:

1. Using the yeast plates you irradiated in Unit III determine whether the mutants you obtained have a nutritional blockage of one of 3 types. The 3 nutritional mutants you will attempt to find are a blockage of a. vitamin synthesis, b. amino acid synthesis, or c. nucleotide base synthesis. To determine whether any of the suspected mutants are of one of these types a transfer of some of each of the mutant cells is made from the complete medium plate to a plate containing minimal medium, a plate containing minimal medium plus a vitamin mixture, a plate having minimal plus an amino acid mixture, and a fourth plate of minimal with a mixture of purines and pyrimidines. After incubation the four plates will be inspected for growth of the transferred cells. If growth occurs in all four plates it is doubtful that the cells tested are mutant types. If growth occurs only on a plate containing supplemental medium, it is reasonable to assume that the mutant is unable to synthesize the substance that was added.

Complete Sheet G-6 and hand in to your instructor.

Post-Evaluation:

1. Complete Activity 1 and Sheet G-6 and hand in.

☐ Complete Instructor's Initials _____

2. Pass the written test for DNA - The key to life with a score of at least 90%.

☐ Complete Instructor's Initials _____

Quest:

Pick out a trait and construct as complete a family pedigree as possible for your own family.

Answer the following questions:

1. Does that trait appear to be dominant or reccessive?

2. Does the trait appear to be sex-linked or autosomal?

Hand in your pedigree, your answers and the justification for your answers.

Advanced Genetics

Sheet G-6

YEAST MUTANTS

Use the chart below to record activity of your mutant with the various media. Indicate growth with (+) and lack of growth with (-).

	Mutant		
Medium	Plate 1	Plate 2	Plate 3
Minimal			
Minimal + Vitamins			
Minimal + Amino Acids			
Minimal + Bases			

Conclusions:

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CURRICULUM

PROJECT

COURSE TITLE: ADVANCED BIOLOGY

PACKAGE TITLE: ADVANCED GENETICS
Unit VI - Probability and Chi-Square

BY

LARRY CHRISTENSEN

Advanced Genetics

Unit VI - Probability and Chi-Square

Rationale:

The Chi-Square (X^2) test is a valuable tool to aid the investigator in determining goodness of fit of a set of data. The test takes into account the size of the sample and the deviations from the expected ratio. The chi-square test allows the investigator to determine the probability that a certain event or events would be the result of chance or whether there is a reason for their occurance.

Probability and statistics are a valuable tool to any scientist if used properly and in order to use or understand statistics you have to know how the statistics were arrived at.

Objectives:

1. You will be able to calculate a probability value for a given set of data using the chi-square method.
2. You will be able to apply the Hardy-Weinberg equation to calculate gene and genotype frequencies in a given population.

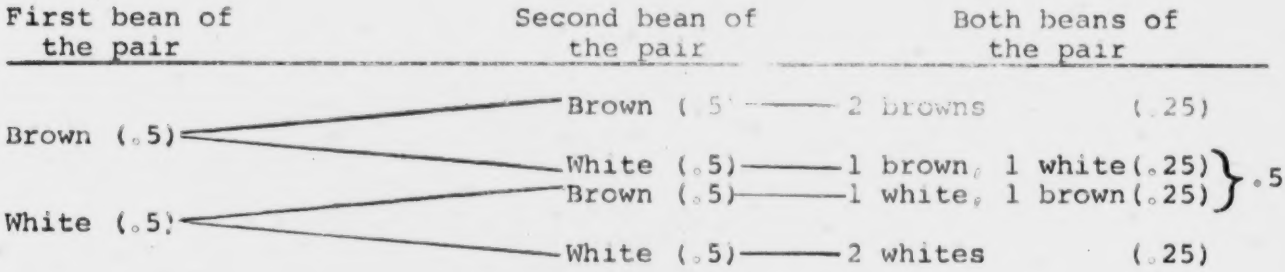
Information Sources:

1. Read and work out the problems in Probability and Chi-Square.
2. Instructor lectures.
3. Read Investigation 18.1 and answer the questions (1-19) on page 685-687 in BSCS - Green Version.
4. Read Chapter 18, pages 390-401 in Principles of Genetics.

Activities:

1. Probability and Chi Square

The purpose of this section is to demonstrate, by using colored beans to represent genetic factors, the relationship of probability to simple genetic ratios. If an equal number of brown and white beans are in a container and two beans are drawn simultaneously at random from the container, the probability that one will be brown is 0.5. The probability that the second bean will be brown is also 0.5. The probability that both beans will be brown is equal to the product of the separate probabilities for each bean being brown or .5 x .5 = .25. If we continue to remove pairs of beans from the container we would obtain three possible combinations of colored beans, two browns per pair, one brown and one white, or two white beans. The probability of the occurrence of these combinations is illustrated in the following diagram.


First bean of the pair
Second bean of the pair
Both beans of the pair
Brown (.5)
White (.5)
Brown (.5) — 2 browns (.25)
White (.5) — 1 brown, 1 white (.25)
Brown (.5) — 1 white, 1 brown (.25)
.5
White (.5) — 2 whites (.25)

(Notice that the probability of any two beans forming a particular combination is equal to the product of the probabilities of the individual beans within the combination).

Let us now use the letter p to designate the probability that one member of a pair of beans will be brown, and the letter q to represent the probability that the other member of the pair will be white. The total probability that a pair of beans will consist of one brown and one white bean will be $p + q = 1$. If these two independent events (p or q) are equally likely to occur then $p = q = .5$. Further, if these two alternate events occur simultaneously the expected frequency of the three different combinations (2 brown beans, 1 brown and 1 white, 2 white) will be given by the binomial $(p + q)^2$ which equals $p^2 + 2pq + q^2$.

Now, to see how probability is related to simple genetic ratios as obtained from a monohybrid cross substitute the factors B (brown color) and b (white color) for p and q in the binomial $(p + q)^2$. The expected frequencies of brown and white factors in the various combinations formed when two beans are drawn at

a time will then be $(B + b)^2$. $(B + b)^2$ will equal $B^2 + 2Bb + b^2$ which to indicate genotypes may be written as 1 BB + 2Bb + 1 bb. From this we can readily see that the expected genotype ratio for brown and white factors will be 1:2:1. This ratio is basic in genetic work and results from a pair of alternative independent events occurring together.

Activity 2:

CHI SQUARE (X^2) TEST FOR GOODNESS OF FIT

A. The 1:2:1 ratio (monohybrid ratio)

a. Count out 200 brown beans and 200 white beans and mix these together in a container.

b. Draw out from this container 100 pairs of beans (200) beans one pair at a time. Record the results of each draw and the totals for the three possible combinations of beans in the chart on page 16.

c. Do the results of the 100 draws fit the expected 1:2:1 ratio? If they do this is unusual for these probabilities are true only as a generalization and do not strictly apply to an individual experiment. Thus, you should expect a deviation of your results from the expected ratio, although the results should be close to the expected ratio. If your observed results do not closely tally with the expected it would indicate that the beans were not thoroughly mixed, or perhaps a size or shape difference between the brown and white beans influenced the drawing technique.

The question, of course, arises as to how close the expected and observed ratios must be to permit the deviation between them to be due to chance alone and not to experimental error. In order to determine if the observed ratio is close enough to the expected ratio to fit it and that the deviation is due only to chance we can utilize a statistical test method (X^2). This test method involves a simply determining the numerical difference between the observed and expected ratios and then, by use of a probability table, how frequently such a deviation might be expected if the experiment were repeated indefinitely.

Suppose in your 100 draws of pairs of beans you obtained 22 with two browns per pair, 51 brown and white, and 27 with both whites. The expected ratios would be 25 with both brown, 50 brown and white, and 25 with both white. By use of the table which follows we can readily determine the deviations between expected and observed ratios and also compute X^2.

Classes (Types of pairs)	Observed Number (o)	Expected Number (e)	Deviation (o-e)	$(o-e)^2$	$\frac{(o-e)^2}{e}$
2 Browns	22	25	-3	9	.36
Brown and White	51	50	+1	1	.02
2 Whites	27	25	+2	4	.16
Totals	100	100	0		.54

$\chi^2 = .54$

Probability (P) = .50 to .80

The column headed classes in the foregoing table describes the three categories of bean pairs which can be drawn. The second column shows the observed numbers of the different types of bean pairs and these numbers total 100. The column headed expected number lists the frequencies of bean pairs expected to occur if the numbers of different classes of bean pairs obtained by 100 draws were to fit a 1:2:1 ratio. Notice this column totals 100, the same as the observed total.

The fourth column (deviation) of the table gives the deviations or numerical differences between the expected and observed number of each type or class of bean pair. Some of these values will be negative numbers and some positive and their sum will always be zero. Since the sum of the deviations is always zero it is of no value as a measure of the total difference between observed and expected ratios. However, by squaring the deviations we obtain only positive values as shown in the fifth column $(o-e)^2$. But these values can not be used directly as a measure of discrepancy since an absolute deviation of 3 from an expected value of 25 is relatively greater than a deviation of 1 in 50 and to square these deviations simply increases the relative differences. To circumvent this final difficulty we can divide the square of the value for the individual deviations by the expected number and thus express the deviations on a relative basis as shown in the final column. (Why not divide the square of the deviation by the observed number?) To obtain chi square (X^2), which measures the total discrepancy between observed and expected ratios, we simply sum the values obtained in the last column which gives us a total of .54. In our sample problem then X^2 has a value of .54.

The chi square value is meaningless, however, unless we can determine how often such a discrepancy is only a matter of chance. In other words, what is the probability of the occurrence of a X^2 value of .54 in our problem if we repeated the experiment again. Fortunately we can determine this probability by use of a Table of Probability. Such a table will be distributed for class use.

In the left hand column of the Table of Probability are given the degrees of freedom (d.f.) which are one less than the number of classes. In our problem the number of classes is 3, hence the degrees of freedom is 2. If we now follow the line of numbers to the right of d.f. 2 we can find a range of chi square values. In our problem X^2 = .54 and this value on the table will fall between .45 and 1.39. These numbers are in columns headed by the probability (P) values of .80 and .50. These P values indicate that in 50% to 80% of the experiments such as we have performed we would obtain a X^2 value as great as .54 purely as a matter of chance. Further, these probability values indicate that our hypothetical or expected ratio of 1:2:1 fits the observed results. In fact, we would expect any particular X^2 value to occur by chance alone as long as its probability exceeded .05 (5%).

WORK OUT X^2 AND P FOR YOUR BEAN DRAWS. RECORD THE RESULTS ON THE WORK SHEET, G-7.

ACTIVITY 3:

The 1:2:2:4:1:2:1:2:1 ratio. (Dihybrid ratio)

a. Mix 400 brown and white beans in one container and 400 speckled and pink beans in another container.

b. Draw out a pair of beans from each container until 100 draws have been made from each container. Record the combinations for all four kinds of beans in the chart on page 16.

Using the symbols W and w for pink and speckled the expected frequencies of the different combinations when the two pairs of beans B,b and W, w are drawn independently are (1 BB + 2Bb + 1 bb) X (1WW + 2Ww + 1ww) = 1 BBWW + 2BBWw + 2 BbWW + 4 BbWw + 1 BBww + 2 Bbww + 1 bbWW + 2 bbWw + 1bbww.

This ratio is one basic in genetic work as obtained from a dihybrid cross. It results when two pairs of alternative independent events occur simultaneously. As before we can compare the hypothetical or expected ratio and the observed ratio to determine if deviations between them are due to chance alone. Once you have calculated X^2 you can then determine the probability of its occurrence. However, the degrees of freedom in this instance will be 8.

WORK OUT X^2 AND P FOR YOUR BEAN DRAWS. RECORD THE RESULTS ON THE WORK SHEET, G-7.

ACTIVITY 4:

Using the data you obtained from your Drosophila population bottles calculate the gene and genotype frequencies of the initial population and terminal population. Explain any differences.

Post-Evaluation:

1. Obtain the written exam for Probability and Chi-square. Passing = 90% correct.

☐ Complete Instructor's Initials_____

2. Hand in work sheet G-7 for grading.

☐ Complete Instructor's Initials_____

3. Hand in your data, gene and genotype frequencies, and conclusions from you Drosophila population study.

Data Sheet - ☐ Complete

Gene and genotype frequencies - ☐ Complete

Conclusions - ☐ Complete

Instructor's Initials_____

4. Hand in questions from Investigation 18.1 BSCS-GV.

☐ Complete Instructor's Initials_____

The following material has been deleted: Work SHeet G-7 Probability

SAHUARITA HIGH SCHOOL

CAREER

CURRICULUM

PROJECT

COURSE TITLE: ADVANCED BIOLOGY

PACKAGE TITLE: ADVANCED GENETICS
Unit VII - The Scientific Paper

BY

LARRY CHRISTENSEN

Advanced Genetics

Unit VII - The Scientific Paper

Rationale:

"Knowledge without communication is ignorance." This is the terminal and perhaps the most important unit in this quarter. If the knowledge you have acquired in the past nine weeks is locked away in your head somewhere then it is useless to anyone but yourself. This is not the objective of the scientific community of which you are a part. Information on experiments, no matter how insignificant it may seem to you, taken together is the basis for our present level of technology.

Objectives:

1. You will be able to write a scientific paper, of publishable quality, communicating the results of your Drosophila crosses using as a model one of the attached papers from a biological journal.

Information Sources:

1. Attached reprints.
2. A.I.B.S. Style Manual.
3. Instructor lectures.

Activities:

1. You will write a scientific paper of publishable quality communicating the results of your Drosophila crosses. You can use any of the attached reprints or the A.I.B.S. Style Manual for your model.

Post-Evaluation:

1. Hand in your report for grading.

☐ Complete Instructor's Initials _____